CLAIMS

1. A fuel cell system comprising:

a fuel gas supply unit supplying fuel gas;

an oxidant gas supply unit supplying oxidant gas;

a fuel cell stack having an anode, from which anode off-gas is expelled, and a cathode, from which cathode off-gas is expelled, that generate electric power upon electrochemical reaction between the fuel gas or the anode off-gas and the oxidant gas;

a catalytic combustor combusting mixed gas between the fuel gas or the anode off-gas and the oxidant gas or the cathode off-gas;

an anode off-gas control valve supplying at least one of the fuel gas and the anode off-gas to the catalytic combustor during an ignition period;

a cathode off-gas control valve supplying at least one of the oxidant gas and the cathode off-gas to the catalytic combustor during the ignition period; and

a controller operative to control the anode off-gas control valve and the cathode off-gas control valve such that at least during the ignition period until the catalytic combustor is discriminated to be sufficiently activated from commencement of supplying the mixed gas to the catalytic combustor, a fuel gas concentration of the mixed gas is maintained in a given range whereas after the ignition period has been elapsed, the mixed gas is available to be supplied to the catalytic combustor even if the fuel gas concentration lying at a value deviated from the given range.

2. The fuel cell system according to claim 1, wherein the controller controls the anode off-gas control valve to allow at least one of the fuel gas and the anode off-gas to be supplied to the catalytic combustor to cause the mixed gas in the catalytic combustor during the ignition period to have an average concentration lying at a given range.

3. The fuel cell system according to claim 2, wherein the controller controls the anode off-gas control valve so as to allow the anode off-gas to be intermittently supplied to the catalytic combustor during the ignition period.

4. The fuel cell system according to claim 2, wherein the controller controls the cathode off-gas control valve to allow at least one of the oxidant gas and the cathode gas to be intermittently supplied to the catalytic combustor at an incremented flow rate during the ignition period.

5. The fuel cell system according to claim 2, wherein the controller controls the oxidant supply unit to allow at least one of the oxidant gas and the cathode off-gas to be supplied to the catalytic combustor at a transiently incremented flow rate during the ignition period.

6. The fuel cell system according to claim 2, wherein the controller controls the oxidant supply unit to allow at least one of the oxidant gas and the cathode off-gas to be supplied to the catalytic combustor at a transiently decremented flow rate during the ignition period.

7. The fuel cell system according to claim 2, wherein the controller controls the anode off-gas control valve so as to allow at least one of the fuel gas and the anode off-gas in the mixed gas to be supplied to the catalytic combustor to be maintained at the maximum concentration lying in the given range during the ignition period.

8. The fuel cell system according to claim 1, wherein the given range is determined to exceed a fuel concentration greater than a value that causes a combustion temperature resulting from the mixed gas reaches an activating temperature of the catalytic combustor.

9. The fuel cell system according to claim 1, wherein the given range is determined to be lower than a concentration forming a flammable limit of the mixed gas.

10. The fuel cell system according to claim 1, wherein the given range is determined to be greater than a concentration at which combustion temperature of the mixed gas reaches an activating temperature of the catalytic combustor and less than a concentration forming a flammable limit of the mixed gas.

11. The fuel cell system according to claim 1, further comprising:

a temperature detector detecting an operating temperature of the catalytic combustor to produce a detection signal indicative of a catalyst temperature lying at a given low level; and

wherein the controller is responsive to the detection signal to open the anode off-gas control valve and to control the cathode off-gas control valve to allow the anode off-gas and the cathode off-gas to be introduced to the catalytic combustor to form the mixed gas therein at a given fuel concentration greater than a catalyst activation lower limit and less than a flammable limit.

12. The fuel cell system according to claim 11, further comprising:

a temperature detector detecting a temperature of the anode off-gas expelled from the anode to provide an anode off-gas temperature signal;

a pressure detector detecting a pressure of the anode off-gas expelled from the anode to provide an anode off-gas pressure signal; and wherein

the controller is responsive to the anode off-gas temperature signal and the anode off-gas pressure signal to estimate a flow rate of the anode off-gas being expelled from the anode, to calculate a demanded flow rate of the

cathode off-gas to be delivered through the cathode off-gas control valve based on an estimated result indicative of the flow rate of the anode off-gas, and to control the opening degree of the cathode off-gas control valve in response to a calculation result.

13. The fuel cell system according to claim 12, wherein the controller stores an anode off-gas supply pattern indicative of the given fuel concentration, and is responsive to the estimated result indicative of the flow rate of the anode off-gas to select the anode off-gas supply pattern for controlling the flow rate of the anode off-gas control valve.

14. A fuel cell system comprising:

fuel gas supply means for supplying fuel gas;

oxidant gas supply means for supplying oxidant gas;

a fuel cell stack having an anode, from which anode off-gas is expelled, and a cathode, from which cathode off-gas is expelled, that generate electric power upon electrochemical reaction between the fuel gas or the anode off-gas and the oxidant gas;

catalytic combustor means for combusting mixed gas between the anode off-gas discharged from the anode of the fuel cell stack and the cathode off-gas discharged from the cathode of the fuel cell stack;

anode off-gas valve means for supplying at least one of the fuel gas and the anode off-gas to the catalytic combustor during an ignition period;

cathode off-gas valve means for supplying at least one of the oxidant gas and the cathode off-gas to the catalytic combustor during the ignition period; and

control means operative to control the anode off-gas valve means and the cathode off-gas valve means such that at least during the ignition period until the catalytic combustor is discriminated to be sufficiently activated from commencement of supplying the mixed gas to the catalytic combustor, a fuel

gas concentration of the mixed gas is maintained in a given range whereas after the ignition period has been elapsed, the mixed gas is supplied to the catalytic combustor even if the fuel gas concentration lying at a value deviated from the given range.

15. A method of operating a fuel cell system having a fuel gas supply unit for supplying fuel gas and an oxidant gas supply unit for supplying oxidant gas, the method comprising:

providing a fuel cell stack having an anode, from which anode off-gas is expelled, and a cathode, from which cathode off-gas is expelled, that generate electric power upon electrochemical reaction between the fuel gas or the anode off-gas and the oxidant gas;

providing a catalytic combustor that combusts mixed gas between the anode off-gas discharged from the anode of the fuel cell stack and the cathode off-gas discharged from the cathode of the fuel cell stack;

supplying at least one of the fuel gas and the anode off-gas to the catalytic combustor during an ignition period;

supplying at least one of the oxidant gas and the cathode off-gas to the catalytic combustor during the ignition period; and

controlling a fuel concentration of the mixed gas to be supplied to the catalytic combustor such that at least during the ignition period until the catalytic combustor is discriminated to be sufficiently activated from commencement of supplying the mixed gas to the catalytic combustor, the fuel gas concentration of the mixed gas is maintained in a given range whereas after the ignition period has been elapsed, the mixed gas is supplied to the catalytic combustor even if the fuel gas concentration lying at a value deviated from the given range.